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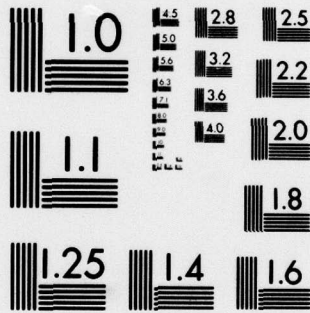
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PRESENTATION OF LSI ST-27

SONAR TRANSMITTING SYSTEM

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LEAR SIEGLER, INC.



DATA AND CONTROLS DIVISION

532 BROAD HOLLOW ROAD
MELVILLE, LONG ISLAND, N. Y. 11746
516-293-9000

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LEAR SIEGLER, INC.



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PRESENTATION OF LSI ST-27
SONAR TRANSMITTING SYSTEM

JANUARY 11, 1968

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AGENDA

1. General Introduction David Martin
VP Marketing
2. Technical Introduction and General
System Description William Loeb
Head, Communication
and Navigation
Engineering Dept.
3. Detailed Technical Description.. Ernest Weiss
Project Engineer
4. Summation and Proposal Mr. Martin

Reference Documents

1. LSi letter to Commander W.F. Wicks dated
December 5, 1967.
2. LSi Technical Proposals:
TP 405 - Improved Sonar Transmission System
Utilizing ST-27 Style Transmitters
TP 407 - Improved Sonar Energy Storage System
Utilizing "Slow" Motor - Alternator Set

TECHNICAL INTRODUCTION

The purpose of this presentation is to acquaint the Navy with what we feel is a unique sonar transmitting system which was developed on a company funded basis. Our extensive previous experience in Radar and Navigation systems has given us background and flexibility in understanding the problems peculiar to sonar systems. Our examination of the system, in concert with Navy technical personnel from Navy Applied Science Labs, Navy Electronics Labs and Navy Underwater Sound Labs, revealed problems in the sonar transmitting system. Our specialized knowledge and experience in the field of power handling and conversion led us to solutions which are practical and feasible and provide significant reliability, cost and operational advantages to the Navy. Navy people have shown a high degree of interest in the work we have performed to date.

The areas to which we have addressed ourselves are the T/R Switch, the transmitter and the energy storage system.

Our primary interest is in the development of a transmitter which has been designated as the ST-27. This system overcomes the majority of limitations of existing systems



in that it has a high degree of reliability and is inherently not subject to failure due to excessive voltage feedback from the transducer system. The basic transmitter is a module with a nominal power output of 1 kilowatt with an overall efficiency of 92%. The output amplitude and phase are locked to the input signal, thus the velocity of the propagated wavefront created at the transducer/water interface is locked to the programmed input signal.

The basic transmitter module can be adapted for use with any active sonar system. We have chosen the SQS-26 as a typical example for comparison purposes.

Figure 1 shows such a typical integrated transmitting system application. The transducer array shown on the left contains 560 elements. We have shown the transducers in phantom since they will not be furnished by LSI. Each element is driven from an ST-27 transmitter as shown toward the center of the figure. A magnetic T-R switch is built in as an integral part of the ST-27 package, thus the outputs shown to the receiving system. Power for the transmitter is direct from the own ship primary power system via an energy storage device. Technical details of the system will be discussed by Mr. Weiss in the next portion of the presentation.



We will now list some of the advantages of the ST-27 and the potential cost savings on a program such as the SQS-26 and other like systems will be self evident.

1. Greater efficiency resulting in power savings 92-93% versus 20-60% efficient.
2. Improved reliability - lower maintenance requirements.
3. Incorporation of the T/R switch reduction in racks and interconnect wiring - up to 40% reduced installation time.
4. The power savings enable the proposal for a simplified energy storage system.

I will now turn the floor over to the Project Engineer, Mr. Weiss, who will discuss the technical details of the system.

SONAR TRANSMITTER ST-27

The ST-27 Sonar Transmitter is a completely self-contained transmitter - T/R Switch Assembly.

The transmitter operates in a closed loop mode whereby the output current is phase locked to the input signal voltage phase, and the real output power is directly proportional to the input signal amplitude.

Figure 2 is a block diagram of the complete Transmitter-T/R Switch Assembly.

Power input into the transmitter is 208 VAC 60 Hz 6 ϕ . This power may be obtained directly from the ships power main through a single distribution transformer for all transmitters or from an energy storage system such as mentioned before. Further, in the event AC power is not available, 220-300 VDC may be used as the power input.

The breadboard that we have here is not equipped to operate from DC nor is it considered standard equipment for the ST-27 Transmitter. A small inverter will be incorporated into the transmitter to generate \pm low voltages required for the control circuits. This power requirement, however, is only 10 watts.

The low voltage requirements are fulfilled by a small power supply. On the block diagram it is indicated as a separate input, as it is in our breadboard, however, in

the final configuration this power will be obtained from one of the 6 phases within the unit.

The preamplifier contains all the control logic necessary for the output stages and it has three (3) inputs:

1. AC control signal; input
2. DC control signal; phase control
3. DC control signal; power output

Output of the preamplifier section feeds the power drivers that, in turn, drive the power output stage.

The unique feature of the output stage is its extremely high efficiency; 98-99% coupled with drastically low output impedance $< 1 \Omega$ regardless whether in operating or standby mode. These characteristics allow the sensing of real power into the load. This sensed real power is compared to the input amplitude and an error voltage in the form of DC serves as one of the inputs into the preamplifier section, thereby closing the power loop of the transmitter.

Phase of the output current is also sensed and it too is compared with the phase of the input signal. Any phase difference will result in a DC error voltage which serves as the second input to the preamplifier. This DC input corrects the output current phase to be identical with the input phase, thereby closing the phase control loop of the transmitter.



Control signal serves as the third input to the transmitter and it may be either sine or square wave having an amplitude range of from 0.5 V P-P to 5 V P-P.

This range was arbitrarily chosen and may be modified if required.

Because of these unique features, accurate power at a specified phase angle is insured even in the presence of high energy sonic environment due to neighboring transducers.

Since both the phase and power are DC controlled within the transmitter, it is possible to program both phase and power using digital information from external programmers. This feature is not incorporated in our breadboard nor is it standard equipment for the ST-27 transmitter, however, this fact is pointed out for its versatility in highly sophisticated systems.

Since the power loop is capable of correcting the output power regardless of the reason whether due to change in load or supply voltage, regulation of the input power is not required. This feature contributes greatly to minimizing parts count and improving reliability of the transmitter.

Our breadboard was designed to operate in the 3-4 KH_z range, however, there is only one frequency sensitive in the transmitter and operation from 1-12 KH_z in 1 or 2 KH_z steps is well within the capability of the transmitter.



Output of the transmitter in its present design consist of two secondary windings to provide additional versatility for matching different transducers.

As an added convenience from the system viewpoint as well as practical considerations, a physically small magnetic T/R Switch is included within the confines of the transmitter. This T/R Switch requires no programming and it operates by sensing the power level on the output lines. In this manner, the receiver is protected whether power is being delivered or received as in a case of a high energy return signal.

Total cycle time for the T/R Switch is $1/2$ cycle of the operating frequency.

Due to the very low output impedance of the transmitter, and the automatic action of the T/R Switch coupled with automatic overload and short circuit protection, renders the ST-27 completely immune to high energy power impulses that may be generated in the transducer due to nearby explosions or severe reverberations.

Reliability of our breadboard is 34,300 hours. Considerable simplification of the control circuits that has been breadboarded as well as the use of integrated circuits instead of discrete component will modify this to approximately 50-55 thousand hours.

Our breadboard has been demonstrated to several interested personnel operating into dummy loads as well



as into actual transducers. During such operations a second transducer was used to receive the transmitted power. The output waveform of the receiving transducer was compared on an oscilloscope against the input waveform into the transmitter without any noticable distortion and a phase angle difference equal only to the time delay of physical displacement of the two transducers.

Summary of performance features

<u>Operational Feature</u>	<u>Possible advantages to Sonar Systems</u>
<p>(1) Efficiency (>92%) Measured as: $\eta = \frac{\text{Power into Transducer}}{\text{Raw Power drawn from ship's own supply}}$</p>	<p>(a) Reduces power needs.</p> <p>(b) Reduces size of energy storage system.</p> <p>(c) Less cooling required</p> <p>(d) More compact construction</p>
(2) Self contained T-R switch (and receiver).	<p>(a) Simplified wiring of systems. Saving approximately 30% of the transmit-receive system wiring</p> <p>(b) Simplified installation. Possibilities of Transmitter-transducer-T-R switch-Receiver miswiring is reduced.</p>
(3) Expositive impulse resistance.	(a) Possibility of damage to receivers in event of "near miss" reduced. (See Figure 2)
(4) Reliability	<p>(a) Less down time</p> <p>(b) Lower skill levels required for handling and installation of transmitter units.</p>
(5) Waveform stability	<p>(a) More uniform transmission through the transducer to water when the power levels are varied.</p> <p>(b) Less variation of phase shift due to resonant frequency variations.</p>

SLOW SPEED ENERGY STORAGE SYSTEM

During demonstrations of our ST-27 Transmitter to interested personnel, it came to our attention that there is need for a simpler, more reliable and less costly energy storage system, than there is in current use on Sonar equipped vessels.

The fact, that our transmitters operate at such high efficiency, permits system operation with smaller amounts of stored energy for the same ping output energy level.

The lesser energy storage requirement permits the use of a small, simple, low speed flywheel - alternator package which Lear Siegler, Inc. is proposing as part of the overall transmitting system.

Figure 4 is a block diagram of such a proposed system.

While this particular system has not been built, Lear Siegler, Inc. has designed and manufactured the control systems for many similar devices.

The motor and alternator are readily available "off-the-shelf" items.

Power from the main line 440 VAC 3Ø 60 H_z is used to drive a motor through an isolating saturable reactor. The motor is directly coupled to a brushless alternator and an energy storage flywheel. The alternator output is



6 ϕ , 208 V 60 Hz provides the necessary power for all the ST-27 transmitters directly. There is no need for any distribution transformers.

There are two regulating loops in the overall control system.

A voltage sampling regulator at the alternator output operates two separate regulating amplifiers. One of these amplifiers drives the control windings on Magnetic Amplifier No. 1 whose output regulates the saturable reactor. This current regulating loop assures that the load impressed on the main power line remains essentially constant for all conditions of operation.

The second amplifier operates the control winding on Magnetic Amplifier No. 2 which acts as a field regulator for the brushless alternator. This loop regulates the output voltage of the alternator for variations in load and rotational speed.

In conjunction, the two regulator loops provide sufficient stabilization to permit direct operation of the transmitters without further regulation.

During ping periods, when power demand is very high, the energy stored in the flywheel provides the necessary energy while simultaneously, the saturable reactor's series impedance increases to isolate the power system from the line to the extent that the load appears essentially constant. During listen mode, the available power



is utilized to restore the speed of the flywheel which has lost 20 % of its speed for the assumed three (3) second ping period.

Based on the system requirements of the SQS-26 CX, detailed calculations have been performed on the energy storage requirements and is presented in Appendix "A" of our Technical Proposal No. 407 starting on Page 8.



2.2

Summary of Performance FeaturesOperational
FeaturePossible Advantages
to Sonar Systems

(1) 1800 rpm system

(a) No gearing or step up frequency changer is required.

- (b) Low acoustic noise
- (c) Longer bearing life
- (d) Less maintenance
- (e) Low cost
- (f) High reliability

(2) Control Saturable Reactor

- (a) Lower line current distortion
- (b) Minimized R.F.I.
- (c) High Reliability
- (d) No line current in rush surges
- (e) Virtually no maintenance required

(3) Brushless Alternator

- (a) Eliminates need for high power distribution transformer.
- (b) Low output resistance eliminates need for fast response output regulator.
- (c) Less maintenance
- (d) High reliability

Overall size of Motor Generator Flywheel = 14' long

Flywheel = 2' diameter 1' thick

Saturable Reactor = 2400 Lbs.

Remainder of control equipment approximately 1/2
of one 19", 7' rack.

In summary, we have presented an integrated Sonar
Transmitting System consisting of a group of highly
efficient and reliable ST-27 transmitters, powered by a
compatible energy storage system.

Because of the flexibility inherent in the ST-27
design, its potential points to universal application in
all types of active Sonar systems, both simple and
sophisticated.

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516-293-9000*

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